

ASDSF 5.2.1 VI

EPA/ROD/R10-91/027  
1991

**EPA Superfund  
Record of Decision:**

**COMMENCEMENT BAY, NEAR SHORE/TIDE FLATS  
EPA ID: WAD980726368  
OU 07  
PIERCE COUNTY, WA  
12/31/1990**

USEPA SF



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THE FOLLOWING QUALITATIVE RISK INFORMATION DEMONSTRATES THAT THE ACTIONS CONTEMPLATED BY THIS INTERIM ACTION ARE NECESSARY TO STABILIZE THE SITE AND PREVENT FURTHER DEGRADATION. THIS INTERIM ACTION WILL ADDRESS SITE RISKS AND CLEANUP OBJECTIVES ASSOCIATED WITH BUILDINGS AND STRUCTURES, INCLUDING THE STACK. IN ADDITION, THIS INTERIM ACTION PARTIALLY ADDRESSES THE POTENTIAL RISKS FROM UNCONTROLLED SURFACE WATER RUNOFF BY ADDRESSING OFF-PROPERTY SURFACE WATER RUN ON. THE FINAL ROD WILL FURTHER ADDRESS ON-SITE RUNOFF. THE COMPLETE RI/FS THAT IS ONGOING WILL EVALUATE THE POTENTIAL HAZARDS ASSOCIATED WITH CONTAMINATED SOILS BENEATH OR SURROUNDING THE BUILDINGS AND STACK, FILL MATERIALS, SITE SURFACE WATER, AND GROUNDWATER. A BASELINE RISK ASSESSMENT ADDRESSING SITE-WIDE CONDITIONS IS A PART OF THE OVERALL RI/FS; DRAFT REPORTS ARE PART OF THE ADMINISTRATIVE RECORD. WHEN COMPLETED, THE RI/FS WILL SUPPORT SELECTION OF A FINAL REMEDIAL ACTION FOR THIS OPERABLE UNIT TO ADDRESS THE REMAINING RISKS.

AT THE ASARCO SMELTER FACILITY THERE ARE SEVERAL MIGRATION AND EXPOSURE PATHWAYS OF CONTAMINANTS WHICH WILL BE PARTIALLY ADDRESSED BY THIS INTERIM REMEDIAL ACTION. BECAUSE THIS WAS A COPPER SMELTING FACILITY, THE CONTAMINANTS OF CONCERN INCLUDE ARSENIC, OTHER METALS AND BYPRODUCTS OF THE COPPER SMELTING PROCESS THAT ARE PRESENT AT THE SITE IN SOILS AND FILL MATERIALS, IN DUST ON OR WITHIN BUILDINGS, AND IN BUILDING MATERIALS. MANY OF THESE CONTAMINANTS ARE TOXIC TO HUMANS AND AQUATIC LIFE INCLUDING:

#### ARSENIC

THE ADVERSE HEALTH EFFECTS FROM EXPOSURE TO ARSENIC HAVE BEEN CONFIRMED IN NUMEROUS PUBLIC HEALTH AND SCIENTIFIC STUDIES. ARSENIC CAN CAUSE A VARIETY OF TOXIC EFFECTS IN HUMANS WITH THE TYPE AND SEVERITY OF EFFECTS DEPENDING UPON THE LEVEL OF EXPOSURE AND FORM OF ARSENIC. INORGANIC ARSENIC IS A HUMAN POISON AND LARGE DOSES CAN CAUSE DEATH. HUMAN EXPOSURE TO LOWER LEVELS OF ARSENIC HAS RESULTED IN INJURY TO A NUMBER OF BODY TISSUES AND ORGANS, INCLUDING THE LIVER, KIDNEYS, NERVOUS SYSTEM, SKIN, AND AN INCREASED RISK OF DEVELOPING LUNG AND SKIN CANCERS. THIS INCREASED RISK OF LUNG CANCER HAS BEEN OBSERVED IN NUMEROUS STUDIES OF WORKERS WHO INHALED ARSENIC IN SMELTERS AND IN A PESTICIDE PLANT. INCREASED INCIDENCE OF SKIN CANCERS HAVE BEEN FOUND IN PEOPLE WHO HAVE CONSUMED DRINKING WATER CONTAMINATED WITH ARSENIC (FOR EXAMPLE, IN TAIWAN AND MEXICO) AND IN THOSE WHO USED MEDICINES CONTAINING ARSENIC.

#### ANTIMONY

ANTIMONY EXPOSURE HAS BEEN ASSOCIATED WITH AN INCREASE IN LUNG CANCER. ANIMAL STUDIES YIELDED SUGGESTIVE EVIDENCE THAT ANTIMONY TRIOXIDE CAUSES LUNG AND LIVER TUMORS. FEMALE WORKERS EXPOSED TO ANTIMONY COMPOUNDS HAD AN INCREASED INCIDENCE OF GYNECOLOGICAL DISORDERS AND SPONTANEOUS ABORTION.

#### CADMIUM

CADMIUM IS RELATIVELY MOBILE IN THE AQUATIC ENVIRONMENT. CADMIUM IS A KNOWN CARCINOGEN TO ANIMALS, AND POTENTIALLY TO HUMANS, EXPOSED BY INHALATION. THERE IS EVIDENCE LINKING CADMIUM WITH CANCER OF THE PROSTATE IN HUMANS.

STUDIES SUGGEST THAT CADMIUM MAY HAVE ADVERSE EFFECTS ON REPRODUCTION IN FISH AT LEVELS PRESENT IN LIGHTLY TO MODERATELY POLLUTED WATERS.

#### CHROMIUM

HEXAVALENT CHROMIUM (CR IV) IS RATHER SOLUBLE AND IS QUITE MOBILE IN GROUNDWATER AND SURFACE WATER. IN THE PRESENCE OF REDUCING AGENTS IT IS RAPIDLY CONVERTED TO TRIVALENT CHROMIUM (CR III), WHICH IS STRONGLY ADSORBED TO SOIL COMPONENTS AND CONSEQUENTLY IS MUCH LESS MOBILE. SOURCES OF CHROMIUM IN AIR INCLUDE WINDBLOWN SOIL AND PARTICULATE EMISSIONS FROM INDUSTRIAL PROCESSES. INHALATION OF CR VI SALTS CAUSES IRRITATION AND INFLAMMATION OF THE NASAL MUCOSA, AND ULCERATION AND PERFORATION OF THE NASAL SEPTUM. HEXAVALENT CHROMIUM CAUSES KIDNEY DAMAGE IN ANIMALS AND HUMANS. THE LIVER IS ALSO SENSITIVE TO THE TOXIC EFFECTS OF CR IV, BUT LESS SO THAN THE KIDNEYS OR RESPIRATORY SYSTEM.

CR III APPEARS TO BE MORE ACUTELY TOXIC TO FISH THAN CR VI; THE REVERSE IS TRUE IN LONG TERM CHRONIC EXPOSURE STUDIES.

#### COPPER

BECAUSE COPPER COMPOUNDS AND COMPLEXES ARE READILY SOLUBLE, COPPER IS VERY MOBILE IN SOIL AND OTHER SURFACE ENVIRONMENTS, AND IS ADSORBED TO ORGANIC MATTER, CLAYS, AND OTHER MATERIALS. IT IS TOXIC TO HUMANS AT HIGH LEVELS CAUSING IRRITATION FOLLOWING ACUTE EXPOSURE AND ANEMIA FOLLOWING CHRONIC EXPOSURE. EXPOSURE TO METALLIC COPPER DUST CAN CAUSE A SHORT-TERM ILLNESS THAT IS CHARACTERIZED BY CHILLS, FEVER, ACHING MUSCLES, DRYNESS OF MOUTH AND THROAT, AND HEADACHE. COPPER IS VERY TOXIC TO AQUATIC ORGANISMS.

#### LEAD

THERE IS SUGGESTIVE EVIDENCE THAT SOME LEAD SALTS ARE CARCINOGENIC, INDUCING KIDNEY TUMORS IN MICE AND RATS. EXPOSURE TO LEAD HAS BEEN LINKED TO REPRODUCTIVE RISK AND IT CAN ADVERSELY AFFECT THE BRAIN AND CENTRAL NERVOUS SYSTEM. CHRONIC EXPOSURE TO LOW LEVELS OF LEAD CAN CAUSE SUBTLE LEARNING DISABILITIES IN CHILDREN. EXPOSURE TO LEAD CAN ALSO CAUSE KIDNEY DAMAGE AND ANEMIA, AND IT MAY HAVE ADVERSE EFFECTS ON THE IMMUNE SYSTEM.

#### NICKEL

IN A NUMBER OF EPIDEMIOLOGICAL STUDIES, OCCUPATIONAL EXPOSURE TO NICKEL COMPOUNDS HAS BEEN ASSOCIATED WITH EXCESS CANCER OF THE LUNG AND NASAL CAVITY. SEVERAL NICKEL COMPOUNDS ARE MUTAGENIC AND CAN CAUSE CELL TRANSFORMATION. IN HUMANS, NICKEL AND NICKEL COMPOUNDS CAN CAUSE A SENSITIZATION DERMATITIS. THE CHRONIC TOXICITY OF NICKEL TO AQUATIC ORGANISMS IS HIGH.

#### ZINC

INGESTION OF EXCESSIVE AMOUNTS OF ZINC MAY CAUSE FEVER, VOMITING, STOMACH CRAMPS, AND DIARRHEA. HIGH LEVELS OF ZINC IN THE DIET HAVE BEEN SHOWN TO ALSO RETARD GROWTH AND PRODUCE DEFECTIVE MINERALIZATION OF BONE. ZINC MAY BE INDIRECTLY IMPORTANT WITH REGARD TO CANCER SINCE ITS PRESENCE SEEMS TO BE NECESSARY FOR THE GROWTH OF TUMORS. (1)

- (1) REFERENCED CHEMICALS SITED FROM: US ENVIRONMENTAL PROTECTION AGENCY (USEPA). 1985. CHEMICAL, PHYSICAL, AND BIOLOGICAL PROPERTIES OF COMPOUNDS PRESENT AT HAZARDOUS WASTE SITES. OFFICE OF WASTE PROGRAMS ENFORCEMENT (OWPE), WASHINGTON, DC.

#### EXPOSURE PATHWAYS

THE EXISTING BUILDINGS AND STRUCTURES CONTAIN DUST AND BUILDING MATERIALS CONTAMINATED FROM EXPOSURE TO INDUSTRIAL ACTIVITIES AT THE SITE. AIR MOVEMENT CAN RELEASE PARTICULATE MATTER WHICH MAY BE TRANSPORTED OFF SITE BY WINDS. PARTICULATE MATTER CAN ALSO SETTLE TO THE GROUND AND CONTAMINATE SOILS AND DUSTS OFF SITE. PEOPLE CAN BE EXPOSED BY INHALING OR INGESTING CONTAMINATED PARTICULATE MATTER. CONTAMINATED BUILDING MATERIALS MAY PRESENT RISKS FROM DIRECT CONTACT.

THE SMELTER STACK PRESENTS ADDITIONAL RISKS. EVALUATIONS OF THE STACK'S STRUCTURAL INTEGRITY FOUND SERIOUS DETERIORATION. THE RESULTS OF A FIELD INVESTIGATION BY ASARCO'S CONSULTANT, WHICH WAS PRESENTED IN DETAIL IN AN ENGINEERING REPORT PREPARED IN 1986 BY INDUSTRIAL CHIMNEY, INC. (SITE STABILIZATION PLAN, PHASE II, APPENDIX C) INDICATES THAT THE STACK, PARTICULARLY THE UPPER SECTION, HAS DETERIORATED CONSIDERABLY BECAUSE OF WEATHER AND SULFATION OF THE MORTAR JOINTS. IF THE STACK WAS TO FALL WITHOUT CONTROLS THERE WOULD BE A SUBSTANTIAL RISK OF INJURY OR DEATH FOR THE ON-SITE PERSONNEL AND THE CLOSELY LOCATED RESIDENCES. IN ADDITION, EXPOSURE FROM INHALATION OF STACK CONTAMINANTS RELEASED INTO THE AIR DURING AN UNCONTROLLED STACK COLLAPSE COULD OCCUR FOR BOTH ON-SITE PERSONNEL AND PEOPLE LIVING IN THE COMMUNITY (APPROXIMATELY 35 HOMES ARE WITHIN 1000 FEET OF THE STACK). THE CONTAMINANTS ALSO COULD SETTLE IN THE NEARBY RESIDENTIAL AREAS, AND PRESENT RISKS FROM DIRECT CONTACT OR INGESTION, AND FROM INHALATION OF RESUSPENDED SOILS AND DUSTS.

A SIGNIFICANT PORTION OF THE SURFACE WATER AT THE SITE FLOWS INTO THE SITE FROM THE 45-ACRE OFF-PROPERTY DRAINAGE BASIN TO THE WEST OF THE ASARCO PROPERTY. MUCH OF THE SURFACE WATER RUNOFF ENTERS STORM WATER DRAINAGE CONDUITS EXISTING AT THE SITE, WHICH DISCHARGE TO COMMENCEMENT BAY VIA THREE OUTFALLS. HOWEVER, THE INTEGRITY OF PORTIONS OF THE DRAINAGE SYSTEM IS IN DOUBT. SEVERAL OBSERVATIONS BASED ON DRAINAGE FLOWS SUGGEST THAT SURFACE WATERS ARE ENTERING THE GROUNDWATER VIA BREAKS IN THE SYSTEM. THUS, THE SITE EVALUATION INDICATES THAT CONTAMINATION IN SURFACE WATER AT THE SITE IS BEING TRANSPORTED TO GROUNDWATER. MUCH OF THIS CONTAMINATED GROUNDWATER BENEATH THE FACILITY FLOWS TOWARD COMMENCEMENT BAY AND MAY BE EXCEEDING EPA'S WATER QUALITY CRITERION AND THE STATE'S WATER QUALITY STANDARDS. THIS MAY RESULT IN RISKS TO AQUATIC LIFE AND TO HUMANS WHO MAY BE EATING AQUATIC LIFE FROM COMMENCEMENT BAY.

ACTUAL OR THREATENED RELEASES OF HAZARDOUS SUBSTANCES FROM THIS SITE, IF NOT ADDRESSED BY IMPLEMENTING THE INTERIM RESPONSE ACTIONS SELECTED IN THIS ROD, MAY PRESENT AN IMMINENT AND SUBSTANTIAL ENDANGERMENT TO PUBLIC HEALTH, WELFARE, OR THE ENVIRONMENT.

#### #DOA

##### DESCRIPTION OF ALTERNATIVES

THE SCOPE OF THE INTERIM REMEDIAL ACTION AT THE ASARCO SITE IS LIMITED AND FEW ALTERNATIVES WERE EVALUATED. FOR ONE OF THE ACTIONS, THE REMOVAL OF EXISTING BUILDINGS AND STRUCTURES OTHER THAN THE STACK, EPA CONSIDERED ONLY CONVENTIONAL TRADE AND PROTECTIVE TECHNIQUES TO DISMANTLE AND DEMOLISH BUILDINGS (SEE SECTION A BELOW, "STRUCTURE DEMOLITION"). ALTHOUGH THE EVALUATION OF APPROACHES FOR DEMOLISHING THE STACK ANALYZED SEVERAL ALTERNATIVES, ONLY ONE APPROACH WAS CONSIDERED EFFECTIVE AND IMPLEMENTABLE DUE TO THE HEIGHT OF THE STACK AND LACK OF STABILITY (SEE SECTION B BELOW, "ALTERNATIVES FOR STACK DEMOLITION"). SEVERAL OPTIONS FOR DISPOSAL OF

DEBRIS WERE CONSIDERED, BUT THE DECISION FOR PERMANENT DISPOSAL OF MATERIAL THAT CANNOT BE REUSED, RECYCLED OR BURNED ON SITE WILL BE MADE IN THE FINAL ROD FOR OPERABLE UNIT 02, ASARCO TACOMA SMELTER. ONLY ONE APPROACH TO DIVERT SURFACE WATER FROM FLOWING ON-SITE WAS DEVELOPED IN THE DRAFT FEASIBILITY STUDY. DESCRIPTIONS OF THE ALTERNATIVES FOLLOW.

#### STRUCTURE DEMOLITION

##### NO ACTION

THE SUPERFUND PROGRAM REQUIRES THAT THE "NO-ACTION" ALTERNATIVE BE CONSIDERED AT EVERY SITE IN ADDITION TO A RANGE OF TREATMENT AND CONTAINMENT ALTERNATIVES. "NO ACTION" WOULD MEAN THAT THE STRUCTURES WOULD NOT BE REMOVED THEREBY IMPEDING THE SAMPLING AND ANALYSIS NECESSARY TO COMPLETE THE RI/FS. "NO ACTION" AND ALSO WOULD RESULT IN CONTAMINANTS REMAINING ON-SITE WHICH COULD BE RESUSPENDED AND RELEASED OFF SITE.

##### CONVENTIONAL DEMOLITION

ALL BUILDINGS INDICATED IN SECTIONS 2-10, SEE FIGURES 3A-I, WILL BE DEMOLISHED OR DISMANTLED BY CONVENTIONAL AND PROTECTIVE METHODS. IN AN EFFORT TO BE CONSISTENT, THE AREAS AND SPECIFIC BUILDINGS AFFECTED ARE SUMMARIZED IN APPENDIX V USING THE NUMBERS AND ORDER ASSIGNED TO THEM IN THE SITE STABILIZATION PLAN. HOWEVER, THE BUILDINGS WILL NOT NECESSARILY BE DEMOLISHED OR DISMANTLED IN THE ORDER LISTED IN APPENDIX V. THE ORDER FOR DEMOLITION WILL BE BASED ON ACCESS NEEDS FOR FURTHER SAMPLING, AND OTHER ON-SITE CONSIDERATIONS.

PRIOR TO DEMOLITION, BUILDINGS AND STRUCTURES WILL BE VACUUMED AND WASHED TO REMOVE DUST, AND ASBESTOS-CONTAINING MATERIALS WILL BE REMOVED. PROPER NOTIFICATION PROCEDURES, IN ACCORDANCE WITH THE ASBESTOS NATIONAL EMISSION STANDARDS FOR HAZARDOUS AIR POLLUTANTS (NESHA), WILL BE FOLLOWED. AREAS OF STRUCTURES CONTAINING DUST THAT ARE INACCESSIBLE FOR VACUUMING WILL BE WASHED DOWN TO CURTAIL DUST EMISSIONS. DURING DEMOLITION, DUST SUPPRESSION MEASURES USING HIGH PRESSURE WATER FOGGING AND MISTING DEVICES WILL BE UTILIZED TO CONTROL THE RELEASE OF DUST AND PARTICULATES. CONTAINMENT SYSTEMS TO COLLECT WATER FROM THE DUST SUPPRESSION MEASURES WILL COLLECT THE WASTE WATER AND ROUTE THE WASTE WATER TO THE EVAPORATION SYSTEM. THESE SYSTEMS WILL MEET EPA REQUIREMENTS.

THIS ROD DOES NOT CALL FOR THE DEMOLITION OF CERTAIN STRUCTURES. SOME OF THESE STRUCTURES, SUCH AS THOSE IN SECTION 9, WILL REMAIN FOR CONTINUED STORAGE AND OTHERS, SUCH AS THOSE IN SECTION 5, WILL REMAIN TO ACT AS RETAINING WALLS FOR TERRACED PORTIONS OF THE SITE. STRUCTURES NOT LISTED IN APPENDIX V WILL BE VACUUMED, EMPTIED AND WASHED DOWN. FOOTINGS, PADS, AND OTHER SUPPORT STRUCTURES FOR SOME OF THE DISMANTLED BUILDINGS WILL REMAIN ON SITE UNTIL THE FINAL REMEDY IS SELECTED. THE FOLLOWING IS A LIST OF THE BUILDINGS, AS REPRESENTED IN THE SITE STABILIZATION PLAN, THAT WILL REMAIN ON SITE AFTER DEMOLITION ACTIVITIES ARE FINISHED.

SECTION 4: SOUTHERN DOCK

SECTION 6: CENTRAL DOCK (COPPER DOCK); NORTHERN DOCK

SECTION 5: NORTHEAST PORTION OF ANODE FURNACES BUILDING; SMALL PORTION OF THE ROOF ADJACENT TO THE ANODE FURNACE AREA; PORTION OF THE WEST WALL IN NO. 3 REFINERY BUILDING

SECTION 7: FINE ORE BINS BUILDING, TRESTLES AND CONVEYOR GALLERIES

SECTION 8: TRANSFORMER HOUSES; TACOMA CITY LIGHT SUBSTATION

SECTION 9: ACID STORAGE TANKS; SETTLING TANKS; EVAPORATION BASIN

##### ALTERNATIVES FOR STACK DEMOLITION

FOR SECTION 1 (SEE FIGURE 3K), THE SMELTER STACK, FIVE DEMOLITION TECHNIQUES, AND TWO OTHER ALTERNATIVES, WERE EVALUATED. THREE OF THE TECHNIQUES INVOLVED DIFFERENT TYPES OF MANUAL DEMOLITION WITH THE USE OF SCAFFOLDING EQUIPMENT. ALSO EVALUATED WERE MECHANICAL DEMOLITION, WITH A CRANE AND HEAVY METAL BALL, EXPLOSIVE DEMOLITION, BY IMPLOSION, CLEANING THE STACK AND NO ACTION.

##### NO ACTION

THE SUPERFUND PROGRAM REQUIRES THAT THE "NO-ACTION" ALTERNATIVE BE CONSIDERED AT EVERY SITE IN ADDITION TO A RANGE OF TREATMENT AND CONTAINMENT ALTERNATIVES. NO ACTION FOR DEMOLITION OF THE STACK WOULD NOT STABILIZE THE DETERIORATING STACK NOR ALLEVIATE THE THREAT OF UNCONTROLLED COLLAPSE (SEE SECTION IV ABOVE, "SUMMARY OF SITE RISKS").

WASTEWATERS GENERATED FROM THE DUST SUPPRESSION SYSTEM WILL BE COLLECTED AT EACH DEMOLITION SITE AND ROUTED TO A WASTEWATER EVAPORATION SYSTEM.

#### ROAD AND TUNNEL SURVEY

IN RESPONSE TO COMMENTS, ROADS USED FOR THE TRANSPORT OF STACK BRICK AND FOR THE TRANSPORT OF DEMOLITION DEBRIS OFF SITE, WILL BE SURVEYED BEFORE RELOCATION OF THE DEBRIS COMMENCES. A RAIL AND CAR TUNNEL SURVEY WILL BE COMPLETED BEFORE AND AFTER DEMOLISHING THE SMELTER STACK TO CONFIRM THAT NO STRUCTURAL DAMAGE WAS CAUSED BY THE IMPACT OF FALLING BRICK.

TRANSPORT OF THE DEBRIS FROM DEMOLISHED SITE STRUCTURES, OTHER THAN THE STACK, TO THE FINE ORE BINS WILL NOT USE RUSTON ROADWAYS OR THE TUNNEL.

#### DEMOLITION OF STRUCTURES

##### BUILDINGS AND STRUCTURES OTHER THAN THE STACK

DEMOLITION OF, OR DISMANTLING OF THE ON-SITE STRUCTURES WILL BE ACCOMPLISHED BY CONVENTIONAL TRADE DEMOLITION TECHNIQUES. APPROXIMATELY 73 STRUCTURES LISTED ON APPENDIX V TO THIS ROD, AS WELL AS MISCELLANEOUS SHEDS, WAREHOUSES, TANKS, BINS AND TRESTLES, WILL BE DEMOLISHED OR DISMANTLED. CONVENTIONAL EQUIPMENT, SUCH AS SHEARS, GRAPPLES, LOADERS, AND CRANES, WILL BE USED WHERE NECESSARY TO SAFELY AND EFFICIENTLY DISMANTLE THE STRUCTURES. TO THE BEST OF EPA'S KNOWLEDGE THERE ARE NO UNDERGROUND STORAGE TANKS AT THE ASARCO FACILITY AS REPRESENTED IN THE RI/FS.

HIGH-PRESSURE WATER FOGGING NOZZLES WILL BE USED TO MINIMIZE DUST EMISSIONS TO THE MAXIMUM EXTENT POSSIBLE DURING DEMOLITION. DURING DEMOLITION, SURFACES NEWLY EXPOSED WILL BE IMMEDIATELY WETTED TO CONTROL DUST. THE EVAPORATION SYSTEM, AS DESCRIBED IN APPENDIX A TO THE ASARCO SITE STABILIZATION PLAN PHASE II, WILL BE DESIGNED TO EVAPORATE THE WATER FROM SOLIDS. THE SOLIDS WILL BE COLLECTED AND STORED IN THE FINE ORE BINS BUILDING OR SENT OFF SITE FOR RECYCLING.

##### SMELTER STACK

THE SMELTER STACK WILL BE DEMOLISHED BY A CONTROLLED EXPLOSIVE DEMOLITION TECHNIQUE KNOWN AS IMPLOSION. THE IMPLOSION WILL BE DESIGNED SO THAT THE STACK DEBRIS WILL COLLAPSE INTO A CONFINED AREA IN WHICH A TRENCH WILL BE CONSTRUCTED TO TEMPORARILY CONTAIN THE STACK BRICKS BEFORE MOVING THE DEBRIS INTO THE FINE ORE BINS BUILDING.

A NUMBER OF PRECAUTIONARY AND SAFETY MEASURES ARE INCLUDED IN THE REMEDY. A DUST SUPPRESSION SYSTEM WILL BE INSTALLED AROUND THE STACK THAT IS DESIGNED TO PREVENT, TO THE MAXIMUM EXTENT PRACTICABLE, THE RELEASE OF DUST AND PARTICULATES DURING THE DEMOLITION. IF PRACTICABLE, AND IF DETERMINED NECESSARY TO SUPPRESS DUST, AN ENCAPSULANT WILL BE APPLIED TO THE INTERIOR LINING OF THE STACK PRIOR TO THE DEMOLITION. SEISMOGRAPH AND AIR BLAST METERS WILL BE INSTALLED TO RECORD GROUND VIBRATION AND AIR PRESSURE GENERATED BY THE EXPLOSIVE DEMOLITION. RESIDENTS LIVING WITHIN 1,000 FEET OF THE STACK, WHICH INCLUDES APPROXIMATELY 35 RESIDENCES, WILL BE ASKED TO EVACUATE DURING THE PERIOD OF STACK DEMOLITION. EVACUATION PROCEDURES WILL BE CONDUCTED WITH LOCAL OFFICIALS. THE DEMOLITION AND MONITORING OF THE DEMOLITION WILL BE CONDUCTED IN CONFORMANCE WITH APPLICABLE FEDERAL AND STATE OCCUPATIONAL SAFETY AND HEALTH REQUIREMENTS, AND WILL CONSIDER GUIDELINES BY THE US BUREAU OF MINES THAT PERTAIN TO OPEN BLASTING.

THE TRENCH INTO WHICH THE STACK DEBRIS WILL FALL WILL BE CONSTRUCTED TO PREVENT ANY DUST SUPPRESSION WASTEWATER FROM PENETRATING THE UNDERLYING SOILS AND GROUND WATER. THE SIDES OF THE TRENCH WILL BE BERMED WITH SOILS FROM THE SMELTER STACK AREA. A FRENCH DRAIN SYSTEM WILL COVER THE BOTTOM OF THE TRENCH. THIS DRAINAGE AREA WILL BE COVERED WITH VISQUEEN TO PREVENT WATER PENETRATION AND A SUFFICIENT COVER OF SAND TO PROTECT THE VISQUEEN FROM PENETRATION BY THE STACK BRICKS.

#### SURFACE WATER CONTROLS

DURING THE DEMOLITION ACTIVITIES NEW SURFACE SOILS WILL BE EXPOSED, AND DEMOLITION DEBRIS WILL BE TEMPORARILY STOCKPILED AROUND THE SITE BEFORE MOVING IT TO THE FINE ORE BINS BUILDING. PRECIPITATION CONTACTING THE DEMOLITION AREA AND WATER GENERATED FROM THE DEMOLITION ACTIVITIES WILL COME IN CONTACT WITH THE EXPOSED SURFACES OF THE DEMOLITION DEBRIS, AND EXPOSED SOILS. THERE IS A POTENTIAL THAT THE WATER MAY PICK UP CONTAMINANTS AND TRANSPORT THEM OFF SITE. SOIL CONTAINMENT AND SURFACE WATER CONTROL MEASURES WILL BE IMPLEMENTED TO MINIMIZE THE POTENTIAL FOR SOIL EROSION AND CONTAMINANT TRANSPORT. THE CONTROL MEASURES INCLUDE THE FOLLOWING:

- SOIL COVER/TRAPS
- SOIL SEALANT/BINDERS
- SURFACE WATER DIVERSION DITCHES
- SOIL BERMS/CONTAINMENT STRUCTURES
- GROUTING KEY DRAINS TO RE-ROUTE POTENTIALLY CONTAMINATED SURFACE WATER TO THE WATER EVAPORATION SYSTEM
- ROUTING COLLECTED SURFACE WATER TO THE EVAPORATION SYSTEM

AS THE DEMOLITION PROCESS TAKES PLACE EACH OF THESE MEASURES WILL BE CONSIDERED ON AN AREA SPECIFIC BASIS AND THE BEST MEASURE OR COMBINATION OF MEASURES WILL BE IMPLEMENTED. SURFACE WATER DISCHARGE POINTS FROM THE SITE WILL BE MONITORED TO ENSURE THAT OUTFALL TO COMMENCEMENT BAY DOES NOT EXCEED DISCHARGE LIMITS ESTABLISHED BY EPA AND THE STATE.

#### AIR MONITORING

TO ENSURE THAT THESE INTERIM ACTIVITIES COMPLY WITH FEDERAL AND STATE AIR QUALITY REQUIREMENTS, AND TO EVALUATE THEIR IMPACT ON AIR QUALITY, AN AMBIENT AIR MONITORING PROGRAM USING HIGH VOLUME SAMPLERS TO TEST FOR METAL PARTICULATES AND AIR SAMPLING EQUIPMENT FOR SEMI-VOLATILE COMPOUNDS, WILL BE IMPLEMENTED DURING SITE PREPARATION WORK AND ALL DEMOLITION AND DISMANTLING ACTIVITIES. ACTION LEVELS WILL BE DETERMINED BASED ON ARARS UNDER THE CLEAN AIR ACT FOR SPECIFIC CONTAMINANTS, AND OTHER HEALTH RISK BASED FACTORS.

#### DISPOSAL OF MATERIALS FROM DEMOLITION ACTIVITIES

DEMOLITION DEBRIS AND MATERIALS FROM THE SITE WILL BE DISPOSED OF IN SEVERAL WAYS, DEPENDING ON THE TYPE OF MATERIAL AND NATURE OF CONTAMINATION. THE APPROPRIATE DISPOSAL OPTION WILL BE APPROVED BY EPA AFTER APPROVED PROTOCOLS FOR SAMPLING AND ANALYSIS ARE USED TO ASSESS THE LEVEL OF RESIDUAL CONTAMINATION AND THE POTENTIAL FOR DECONTAMINATION OF THE MATERIAL. AS DEMOLITION DEBRIS IS GENERATED, IT WILL EITHER BE STORED ON SITE IN THE FINE ORE BINS BUILDING UNTIL A FINAL DISPOSAL REMEDY IS SELECTED OR DISPOSED IN AN OFF-SITE DISPOSAL SITE APPROVED BY EPA. NON- OR DE-CONTAMINATED DEBRIS CAN BE REUSED OR RECYCLED.

#### TEMPORARY ON-SITE DISPOSAL IN FINE ORE BINS BUILDING

THE FINE ORE BINS, AN ENCLOSED CONCRETE BUILDING WITH A ROOF WITHIN THE AREA OF CONTAMINATION, WILL BE USED FOR THE TEMPORARY STORAGE OF DEMOLITION DEBRIS TO PREVENT THE RELEASE OF HAZARDOUS AND DANGEROUS WASTES INTO THE ENVIRONMENT. THE STORAGE OF DEMOLITION DEBRIS WILL MEET THE WASTE PILE REQUIREMENTS OF HAZARDOUS WASTE FACILITIES (SEE FOOTNOTE 5 BELOW). ALL FORMS OF DEMOLITION DEBRIS FROM BUILDINGS AND THE STACK MAY BE STORED IN THE FINE ORE BINS BUILDING PENDING SELECTION OF A PERMANENT DISPOSAL REMEDY IN THE FINAL ROD FOR THIS SITE. PRIOR TO STORAGE IN THE FINE ORE BINS, THE MATERIALS WILL UNDERGO A WASTE ANALYSIS TO IDENTIFY THE TYPE AND LEVEL OF CONTAMINATION.

THE STACK BRICKS WILL BE LOADED INTO TRUCKS FROM THE TRENCHED AREA AND TAKEN TO THE FINE ORE BINS BUILDING. HAULING THE STACK DEBRIS WILL REQUIRE TRAVEL ON PUBLIC ROADWAYS, AND REQUIRE DECONTAMINATION OF HAUL TRUCKS AT THE LOADING/UNLOADING AREAS.

CONCRETE, STEEL, WOOD, OR OTHER TYPES OF DEBRIS THAT CANNOT BE DECONTAMINATED FOR REUSE OR RECYCLED, OR, IN THE CASE OF WOOD, WHICH CANNOT BE INCINERATED, WILL BE STORED SO THAT THE MATERIALS MAY BE SEGREGATED BY TYPE OF MATERIAL OR CONTAMINATION.

#### ON-SITE INCINERATION

WOOD MATERIALS WILL BE SAMPLED TO DETERMINE IF THEY ARE DANGEROUS OR HAZARDOUS WASTES. WOOD WHICH IS NOT A HAZARDOUS OR A DANGEROUS WASTE WILL BE INCINERATED ON SITE IN A MODIFIED PRODUCTION VESSEL CALLED A CONVERTER. MATERIALS THAT ARE CONSIDERED HAZARDOUS OR DANGEROUS WASTE WILL NOT BE BURNED IN THE INCINERATOR, WHICH IS NOT DESIGNED TO COMPLY WITH THE HAZARDOUS WASTE INCINERATOR REQUIREMENTS. THE VOLUME OF WOOD IS EXPECTED TO BE 10,500 CUBIC YARDS. IF THE INCINERATOR CANNOT MEET EMISSION REQUIREMENTS, THE WOOD DEBRIS WILL BE EITHER SHIPPED OFF SITE FOR DISPOSAL OR STORED ON SITE IN THE UPGRADED FINE ORE BINS BUILDING PENDING SELECTION OF THE FINAL REMEDY.

#### OFF-SITE DISPOSAL

DEMOLITION DEBRIS CAN BE SHIPPED OFF SITE FOR DISPOSAL IN AN APPROPRIATE FACILITY, DEPENDING ON THE NATURE OF CONTAMINATION. ALL MATERIAL WILL UNDERGO A WASTE ANALYSIS PRIOR TO SHIPMENT OFF SITE. ALL OFF-SITE DISPOSAL FACILITIES MUST BE OPERATING IN COMPLIANCE WITH APPLICABLE FEDERAL OR STATE LAWS AND EPA'S OFF-SITE DISPOSAL POLICY BEFORE THE MATERIAL IS SHIPPED. HAZARDOUS WASTE BOUND FOR OFF-SITE DISPOSAL MUST BE DISPOSED IN A HAZARDOUS WASTE DISPOSAL FACILITY. DANGEROUS WASTE WILL BE EVALUATED TO DETERMINE WHETHER IT IS ALSO A HAZARDOUS WASTE BEFORE SHIPMENT TO IDENTIFY THE TYPE OF FACILITY THAT IS APPROPRIATE. ASBESTOS-CONTAINING MATERIALS WILL BE DISPOSED AT A FACILITY OPERATING IN ACCORDANCE WITH FEDERAL NESHAPS REGULATIONS AND

By the end of 1994, 75 private properties had been cleaned up and 269 yards had been sampled.

#### **4.2.2 OU 06 - Asarco Sediments**

EPA issued a Supplemental Feasibility Study for the off-shore sediments in summer 1993. However, EPA, Ecology, Asarco, the Natural Resource Trustees and a community group believed that additional investigations and evaluation of the cleanup actions were necessary. In 1994, Asarco and EPA entered into an AOC requiring Asarco to collect and evaluate additional information regarding the off-shore marine sediments.

#### **4.2.3 OU 07 - Demolition and Surface Water Controls**

In November 1994, Asarco completed Phase II demolition of remaining Site structures under a federal Consent Decree signed in 1991 with EPA. Also under the Consent Decree, Asarco controls surface water that runs onto the Site to minimize the contact of surface water with contaminated soil in the cooling pond.

The remainder of this ROD discusses only the source control activities for cleanup of OU 02, the former Asarco Smelter, and the final disposal of demolition debris, the ERA soils and the Ruston/North Tacoma residential soils.

### **5.0 SUMMARY OF SITE CHARACTERISTICS**

Under EPA's oversight, Asarco collected and analyzed soil, slag, surface and ground water, and sediment samples at the Site.

Soil. The following contaminants were found in soils on the Site at levels that were of potential concern to human health and the environment:

#### **Metals**

Antimony, Arsenic, Cadmium, Copper, Lead, Mercury, Silver, Thallium, Zinc

#### **Organic Chemicals**

Polyaromatic Hydrocarbons (PAHs) and Polychlorinated Biphenyls (PCBs)

These contaminants in soil are of concern because (1) they are the primary source of contamination to ground water and surface water that is flowing into Commencement Bay; and (2) they are a potential health concern for humans and animal life that be exposed to the contaminants in the soil now or in the future.

Samples show that the principal threats to human health and the environment posed by the Asarco Site are the contaminated materials in the six "source areas" identified on Figure 1-1.

These are areas that have either the highest measured concentrations of contaminants in the soils, appear to act as the primary known sources of contamination to ground water and surface water, and/or have large amounts of contaminated material based upon the historic uses of these areas.<sup>3</sup> These areas are the:

- Stack Hill
- Copper Refinery Area
- Cooling Pond
- Fine Ore Bins Building
- Arsenic Kitchen
- Southeast Area of the Plant

<sup>3</sup> For example, the highest concentration of arsenic found in soil is 403,100 parts per million (ppm) near the arsenic kitchen area. This level is approximately 130 times higher than the highest concentration found in Ruston. The highest concentration of arsenic in ground water is located in monitoring well 111 with 52 ppm (.006 parts per million is EPA's preliminary remedial action objective). This monitoring well is down-gradient from the arsenic kitchen and fine ore bins area. See Table 3 for maximum concentrations of chemicals of concern.

Soil and groundwater concentrations in the source areas are identified for both arsenic and copper in Tables B-3 and B-4, respectively, in Appendix B.

In addition to these six areas, elevated concentrations of metals were detected in soils and slag throughout the entire property. Even though certain areas are not considered principal threats to ground water, the concentrations generally are high enough throughout the Site to pose a threat if they are inhaled, ingested, or touched by people or animals.

Slag contains high concentrations of metals, including arsenic and lead, in a rock-like form. Concentrations of arsenic found in slag ranged from 100 to 24,950 ppm. The slag along the smelter shoreline is a poured matrix. The slag found on the slag peninsula is primarily fine grained, sand-like particles. The slag portions on the Site appear to contribute less contamination to ground water than the source areas described above. Slag poses a threat if ingested by people or animals. In addition, the fine slag particles on the peninsula are blown into Commencement Bay and potentially into the recreational areas of the Yacht Basin and Point Defiance Park.

The face of the slag shoreline appears to be impacted by the tidal activity in Commencement Bay. High energy currents and wave action cause erosion of the slag, which results in slag particles moving from the shoreline and being deposited into the off-shore sediments. Recently, a shoreline monitoring station was washed away.

Surface water samples were collected from seeps (ground water that surfaces from hillsides or in the tunnel), puddles, and at the outfalls that discharge into Commencement Bay. Asarco found that surface water on the Site, including seeps and small stagnant pools below the stack hill and in the arsenic kitchen area, and water in the cooling pond, is contaminated with metals at levels higher than federal or state standards for drinking water and for protection of sea life. The contaminants that exceed regulatory levels include arsenic, beryllium, cadmium, chromium, copper, lead, mercury, nickel selenium, silver zinc, total petroleum hydrocarbons, and anilines.

The surface water investigation showed that the surface water drainage system on the Site is no longer adequate. The pipes and drains associated with the system may be cracked and/or the pipes filled with contaminated sediments. Surface water can become contaminated by contact with the contaminated sediments in the pipes. The contaminated surface water can then leak out of the system and migrate to ground water or discharge to Commencement Bay.

Ground Water. Three water-bearing zones (groundwater aquifers) were identified at the smelter property. The two shallowest aquifers, the slag and marine sands aquifers, show elevated levels of arsenic, copper, zinc, and other metals. A thick silt barrier between the shallow and deeper aquifers seems to have protected the deeper aquifer, the Pre-Vashon aquifer, from contamination. Only a few water samples from the deeper aquifer have elevated metal concentrations. The few exceptions may result from contamination migrating through a production well, which was drilled into the deeper aquifer during the smelter's operation. This well has now been plugged so that contamination is unlikely to continue migrating from this well into the deeper aquifer.

The three primary ways for metals to move into ground water are: (1) clean or contaminated surface water moving through contaminated soil into ground water; (2) contact between ground water and soil or slag that releases metals into ground water; and (3) leakage and spills, for example, from former process operations such as ore handling, storage, or refining, and from the existing sewer and drainage system.

Organic contamination caused by dimethylaniline (DMA) that was used in the production of sulfuric acid has been identified in the southeast corner of the smelter property. Wood debris and sawdust, left over from sawmill operations and now buried beneath the slag, are decomposing thus contributing to the release of metals, particularly arsenic, from the slag into ground water and Commencement Bay.

The metal levels in ground water decrease as ground water moves through the smelter property towards Commencement Bay. This decrease in contamination may be due to: (1) seawater or groundwater dilution; (2) metals adhering to the slag as ground water moves towards the bay; (3) metals being removed from the ground water through chemical reactions; or (4) the contaminant plume moving slowly through the smelter property.



The contaminants that exceed regulatory levels for ground water entering the bay are: arsenic, beryllium, cadmium, copper, lead, mercury, nickel, selenium, silver, zinc, total petroleum hydrocarbons, and anilines.

Air. Samples of dust were collected at 22 smelter property locations. A model was used to predict how much dust would move into the communities of Ruston and Tacoma if there were no cleanup. The results showed that the highest emissions would be on the smelter property and that emission levels decrease rapidly with distance from the smelter property.

## **6.0 DESCRIPTION OF SITE RISKS**

This section of the ROD provides a brief summary of the "On-Property Human Health Risk Assessment" ('Risk Assessment') for the Asarco Tacoma Plant (Kleinfelder 1993). The document was prepared by Asarco, with EPA oversight, to assess the potential human health risks from Site contamination and was completed according to national and regional EPA risk assessment guidelines. It evaluates potential risk from exposure to contamination in soil, slag, surface water, ground water and air if no remedial action is taken on the site. The results of this assessment were used to decide whether remedial action is appropriate and which exposure pathways and contaminants require remediation.

### **OVERALL SUMMARY OF RISK ASSESSMENT**

Potential health impacts were estimated using the risk assessment and assuming five possible land-use scenarios for the Site: residential, industrial, commercial, recreational and the existing non-use. The result showed that the estimated cancer risks and non-cancer health effects from the Site are the highest for possible future residents who may inadvertently ingest soils or drink ground water at the site. For example, it was estimated that the lifetime chance of developing cancer from ingesting soil in the arsenic kitchen area, assuming residential use (e.g., daily ingestion of soil, a 70 kilogram adult, living on the Site for 30 years), may be as high as two in ten. Repeatedly ingesting soil in the stack hill area may pose a chance of four in a hundred of getting cancer. An unacceptable excess lifetime cancer risk for Superfund cleanups is in a range of approximately one in ten thousand to one in a million. Non-cancer impacts from the Site are likely to present appreciable risk of significant adverse effects to people over lifetime exposures (generally referred to as a hazard index (HI) greater than one).

Residential land use poses the highest potential for health impacts because it assumes that people will spend the most time at the property and therefore potentially be more exposed to contaminants. Other land use possibilities, such as recreational, industrial, commercial, and non-use, assume people will spend less time at the Site and have lower exposures to Site contaminants. Therefore, these other scenarios are estimated to have less potential for health impacts.

Arsenic exposure is responsible for most of the estimated cancer risk from contaminants in soil, slag, ground water and surface water at the Site. Arsenic levels in the surface water and ground water that is discharged to the Bay substantially exceed EPA's water quality criteria for fish ingestion by people, and state standards that protect marine life. Antimony, arsenic, chromium, copper, lead, manganese, and mercury are some of the chemicals of most concern for non-cancer effects such as organ damage, learning disabilities, and birth defects. A detailed discussion of all of the assumptions and the estimated numerical health impacts associated with each pathway can be found in the Risk Assessment report.

Risk assessments are performed using information on the toxicity of contaminants and assumptions regarding the extent to which people may be exposed to them. This summary of the Asarco Risk Assessment is divided into five sections: (6.1) identification of contaminants of concern (COCs), (6.2) exposure assessment, (6.3) toxicity assessment, (6.4) risk characterization, which is an integration and summary of the information gathered and analyzed in the preceding sections, and (6.5) analysis of the uncertainty involved in developing a risk assessment. In addition, Section 6.6 is a summary of the qualitative ecological risk assessment (EPA 1993).

### **6.1 IDENTIFICATION OF CONTAMINANTS OF CONCERN (SCREENING ANALYSIS)**

The selection of chemicals that potentially contribute to risks to human health at the Site, known as the COCs, was a two-step process. First a screening evaluation was done comparing the

maximum chemical concentrations in soil, ground water, and air with conservative health-based concentrations and/or with appropriate criteria and standards. The chemicals selected in this first step were then evaluated, taking into account each chemical's frequency of detection, toxicity, persistence and mobility, in order to select the final COCs in each media. These are shown in Table 6-1.

Chemicals selected for soils, Class IIB ground water (potential drinking water) and air shown in Table 6-1 were selected using exposure parameters based on residential use of the Site.

Water from Class III wells is not suitable for drinking, it contains contaminants and can migrate into the bay. The COCs for Class III ground water were selected base upon the potential for humans to be exposed to these contaminants through consumption of seafood from the bay. Five metals were selected: arsenic, beryllium, lead, manganese and mercury.

All of the metals selected as COCs in ground water and soil were selected as COCs in surface water. Arsenic and lead were selected as COCs of concern in slag based upon information from the Ruston/North Tacoma Risk assessment.

## **6.2 EXPOSURE ASSESSMENT**

The exposure assessment estimates the type and magnitude of exposures to the COCs at the Site. It considers the current and potential future uses of the site, characterizes the potentially exposed populations, identifies the important exposure pathways and quantifies the intake of each COC from each medium for each population at risk. The result of the assessment is a calculated daily dose of each COC per body weight for each exposure medium.

### **6.2.1 Identification of Site Uses, Exposed Populations and Exposure Pathways**

Site Use Scenarios. The exposure assessment for the Asarco Site considers five land-use scenarios involving different groups of potentially exposed populations. Of the five land-use scenarios considered, one represents the current use or "non-use," and four represent projected future uses: residential, commercial, heavy industrial, and recreational.

Potentially Exposed Populations. Each scenario described above has an associated population that may be exposed to COCs at the site. The populations assumed for each of the site uses are described below.

- (1) Non-Use. Currently, the Site is not being used for any purpose other than for site investigation, monitoring and demolition. For this existing use scenario, potentially exposed populations are maintenance workers, guards, trespassers and nearby residents who may be exposed to dust from the Site.
- (2) Residential. The Site would be developed for residential use. People would spend 30 years of their lifetime on the Site.
- (3) Heavy Industrial. The Site would be developed for industrial purposes. Workers would spend 25 years of continuous employment at the Site.
- (4) Recreational or Park. All or part of the Site would be developed as a park. Visiting children and adults would be exposed to Site contaminants.
- (5) Commercial. Part or all of the Site would be redeveloped for commercial uses including office buildings and shops. Office workers and merchants would be the primary exposed populations.

TABLE 6-1. CONTAMINANTS OF CONCERN FOR SOIL, GROUND WATER AND AIR

Chemical	Soil	Drinking Water	Ground water Impacting the Bay	Air
Antimony	N	N		
Arsenic	C/N	C/N	C/N	C/N
Beryllium		C/N	C/N	
Cadmium	C/N	C/N		C/N
Chromium		C/N		C/N
Copper	N	N		
Lead	C/N	C/N	C/N	C/N
Manganese		N	N	
Mercury	N		N	N
Nickel		C/N		C/N
Selenium				
Silver	N	N		
Thallium	N			
Zinc	N			
Polycyclic Aromatic Hydrocarbons	C			
Polychlorinated Biphenyls	C			

C Cancer Causing Chemical

N Chemical Causing Non-Cancer Health Effects

C/N Chemical Causing Both Cancer and Non-Cancer Effect

Exposure Pathways. An exposure pathway is the mechanism by which chemicals migrate from their source or point of release to the population at risk. Four elements comprise a complete exposure pathway: (1) a source of a chemical release (e.g., contaminated soils); (2) movement of contaminants through environmental media (e.g., rain moving through contaminated soil into ground water); (3) a point of potential human contact with a contaminated medium (e.g., use of contaminated ground water for drinking water); and (4) entry into the body or exposure route (e.g., ingestion of drinking water).

The exposure pathways considered for the Risk Assessment varied depending on the land use being considered and on the population potentially exposed. For example, in assuming future residential land use of the Site, the following exposures were evaluated for adults and children: (1) ingestion of slag, soil, and dust; (2) dermal exposure to soil and dust; (3) ingestion of vegetables potentially contaminated by soil contaminants; (4) inhalation of contaminants in the air as a result of dust resuspension from the site; (5) ingestion of potable ground water on the Site; and (6) ingestion of contaminated surface water in pools and seeps on the Site.

In contrast, the potential exposures considered for a site maintenance worker under the current non-use scenario were: (1) ingestion of soil, dust, and slag; (2) dermal exposure to soil and dust; and (3) inhalation of contaminants in dust.

#### **6.2.2 Calculation of Exposure**

EPA's Superfund guidance requires that the reasonable maximum exposure (RME) be used to calculate potential health impacts at Superfund sites. The RME is the highest exposure that is reasonably expected to occur at the site. It is calculated using conservative assumptions in order to represent exposures that are both reasonable and protective. In the Risk Assessment, RMEs were estimated for the land-use scenarios and exposure pathways described above (see Table B-5 in Appendix B for the RME exposure assumptions for potential residential use). For the residential scenario, average exposures were calculated in addition to the RMEs to represent exposures of a more typical person.

To estimate exposure, data on the concentrations of COCs in the media of concern at Site (the exposure point concentrations) are combined with information about the projected behaviors and characteristics of the people who may potentially be exposed to these media (exposure parameters). These elements of the Asarco Site are described below.

Exposure Point Concentrations: The Site was divided into six areas to calculate the contaminant levels for estimating exposure because the Site is large, the types and concentrations of contaminants vary by area, and there are several possible future land-use scenarios, see Figure 6-1. The areas are (1) the administrative area; (2) arsenic kitchen area; (3) cooling pond area; (4) stack hill area; (5) off-plant area; and (6) general plant slag area. Section 3.0 of the Risk Assessment presents details on the calculations and use of these exposure point concentrations.

Parameters: The parameters used to calculate the RME include body weight, age, contact rate, frequency of exposure and exposure duration. Exposure parameters provided in EPA Superfund guidance were used when available (i.e., for the residential and heavy industrial land uses). Parameters for the other land uses were developed for the Asarco Site using best professional judgement.

For all of the media, except surface water, exposures were estimated assuming long-term exposures to site contaminants (e.g., 30 years of daily use for residential use, 350 days/year, and 25 years, 8 hours/day for 5 days/week, for heavy industrial use). Potential risk from surface water was calculated assuming that a child accidentally consumes water that has puddled on the Site. Since there were no data on contaminant levels in Commencement Bay for fish, potential risks from the consumption of fish and shellfish were estimated by comparing the levels of contaminants in selected shoreline wells with EPA's WQC for protection of human health from fish consumption.

### **6.3 TOXICITY ASSESSMENT**

The purpose of the toxicity assessment is to provide, where possible, an estimate of the

relationship between the extent of exposure to a contaminant and the increased likelihood and/or severity of adverse effects. This is done by weighing available evidence regarding the potential for particular contaminants to cause adverse effects in exposed individuals.

EPA has conducted toxicity assessments for many chemicals and publishes the resulting values, slope factors (Sfs) and reference doses (RfDs), on the Integrated Risk Information System (IRIS) or in the Health Effects Assessment Summary Tables (HEAST). With the exception of lead, which is assessed using the integrated uptake/biokinetic model (IUBK) developed by EPA, IRIS and HEAST were used as a source for Sfs and RfDs.

Sfs have been developed for estimating upper-bound excess lifetime cancer risks associated with exposure to potential cancer-causing chemicals. They are expressed in units of the inverse of milligrams per kilogram of body weight per day (mg/kg-day)<sup>-1</sup>. S/S are derived from the results of human epidemiological studies or chronic animal bioassays to which mathematical extrapolations from high to low dose and from animal to human have been applied, see Table B-6 in Appendix B.

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RfDs have been developed to indicate the potential for adverse health effects from ingestion of COCs that exhibit non-cancer effects, such as damage to organ systems (e.g., the nervous system, blood forming system, etc.) and learning disabilities. They are expressed in units of mg/kg-per day. RfDs are estimates within an order of magnitude, of lifetime daily exposure levels for people, including sensitive individuals, that are likely to be without risk of adverse effect. Estimated contact with contaminant(s) of concern from environmental media can be compared to the RfD (e.g., the amount of a contaminant(s) of concern ingested from drinking water or soil in mg/kg/day). Reference concentrations (RfCs) are used to indicate potential non-cancer health impacts from inhalation (usually expressed in milligram per cubic meter), see Table B-7 in Appendix B.

The standard non-cancer risk assessment method described above was not used for the assessment of lead in soil. For the residential scenario, EPA guidelines specify the use of the IUBK model for estimating acceptable lead levels in soil. EPA guidance recommends that soil lead concentrations should be low enough to ensure that blood lead levels do not exceed 10 micrograms per deciliter in 95% of the potentially exposed children. The IUBK model predicts a value of 500 ppm of lead in soil to meet this goal. The exposure point concentrations calculated for lead in soil at the Site were compared to this value of 500 ppm to assess its potential non-cancer impacts.<sup>4</sup>

- 4 Since the Risk Assessment was completed, the IUBK model has been revised. The most recent version of the IUBK model results in lead levels of 400 ppm. EPA does not believe that this significantly alters any of the conclusions in the Risk Assessment and does not have an impact upon any Site cleanup decisions.

#### 6.4 RISK CHARACTERIZATION

Risk characterization is an integration and summary of the information gathered and analyzed in the preceding sections. Site-specific exposure estimates were combined with cancer Sfs and RfDs to assess potential health impacts.

To estimate cancer risk, the Sf is multiplied by the exposure expected for that chemical to provide an upper-bound estimate of the excess lifetime cancer risk. This estimate is the incremental probability of an individual developing cancer over a lifetime as a result of exposure to cancer-causing chemicals at a site.

The potential for non-cancer health impacts is evaluated by dividing the exposures calculated for each COC at the site by its RfD or RfC. The result is the Hazard Quotient (HQ). By adding the HQs for all contaminants via one exposure pathway, the HI is calculated.

The results of the Risk Assessment show that the estimated cancer and non-cancer impacts from exposure to Site contaminants in soil vary with the Site areas and with the projected future land-use. The estimated lifetime cancer risk from ingesting soil in the arsenic kitchen area, assuming residential land use, may be up to two chances in ten (2 in 10). Cancer risks in the

other five areas of the Site, assuming residential land use, range from about 4 chances in 100 to 2 chances in a 1,000. These risks are lower primarily because contaminant levels are high in the arsenic kitchen area than in the rest of the Site.

Residential exposure to soils in the arsenic kitchen area is estimated to result in an excess cancer risk of 2 chances in 10, but the risks for the other possible site-uses (industrial, commercial, recreational and non-use) in the arsenic kitchen area range from 5 chances in 100 to 2 chances in 1,000. Residential use assumptions result in the highest risks because exposures occur more often and over longer periods of time, more exposure routes are possible and children have higher exposures than adults.

Cancer risks vary by route of exposure. For example, for residential exposures in the arsenic kitchen area, ingestion of soil contaminants results in the highest cancer risk (2 chances in 10) followed by exposure to contaminants in drinking water (about 4 chances in 100), eating vegetables (3 chances in 1,000), inhaling contaminants in dust (5 chances in 10,000) and dermal exposure to soils (5 chances in 100,000), see Figure B-1 in Appendix B.

According to the National Contingency Plan, which governs Superfund cleanup, if the cumulative cancer risk on a site is greater than approximately 1 in 10,000, a cleanup action is generally taken.

The estimated HI, which is used to evaluate non-cancer impacts, is 806 in the arsenic kitchen area assuming soil ingestion and residential land-use. HIs in this area for other land uses range from 7 to 205, see Figure B-2 in Appendix B. The HI for ground water ingestion in the arsenic kitchen area assuming residential land use is 219. HIs above 1 are used in the Superfund program to indicate that site remediation may be necessary.

Arsenic is responsible for the majority of the cancer risk at the Site. Several metals, including arsenic, lead, and copper are responsible for the non-cancer impacts at the Site.

Exposures to arsenic, copper and lead in site surface water may result in acute hazard to children who swallow this surface water. The concentrations of four metals, arsenic, mercury, manganese and beryllium, in Class III ground water near the bay are in excess (above a 1 in 10,000 cancer risk or above RfDs) of EPA's water quality criteria for protection of human health from fish consumption. Aniline is in Class III ground water at concentrations that exceed a risk of 1 in 10,000 assuming fish consumption.

Although the Risk Assessment did not include an evaluation on the adjacent slag peninsula, potential health impacts in this area are expected to be similar to those in Area 6, the general plant slag area. Area 6 was evaluated in the Risk Assessment for arsenic exposure. Assuming residential exposures, cancer risk in Area 6 may be as high as 2 in 1,000 and the HI is above 1. Therefore, both the slag peninsula and the general plant slag area contain arsenic at levels that may result in cancer and non-cancer risks above Superfund levels of concern.

## **6.5 UNCERTAINTY ANALYSIS**

The numerical results of a risk assessment (HQs and cancer risk values) are uncertain because of limitations in knowledge regarding exposure and toxicity. Where information is incomplete, assumptions must be made: the greater the uncertainty, the more conservative the assumptions to be protective of public health. Even when actual characteristics of a population are known, selected exposure parameters are biased toward over-estimating rather than under-estimating risk for the majority of the population. A discussion is presented below on how uncertainties in the risk assessment process might overestimate or underestimate risk.

Some of the factors that may lead to a possible overestimation of risk are as follows:

- (1) The majority of the soil samples were collected in areas of the Site thought to be contaminated based on past smelter operations, so the whole Site might not be as contaminated as these samples indicate;
- (2) Because of a lack of information, the exposure parameters (e.g., exposure frequency and duration) used in the risk assessment are derived in a conservative manner;

## 7.0 DESCRIPTION OF ALTERNATIVES

Asarco's Feasibility Study (FS) identified a range of alternatives to achieve the clean up objectives and remediation goals for the smelter property and slag peninsula (Table 7-1). The alternatives represent significantly different approaches to cleanup the Site and protect human health and the environment. The alternatives are different, for example, in terms of their effect on the contamination, what is necessary to maintain their effectiveness, and their cost.

The range of alternatives presents several choices for cleaning up contamination at the Site. EPA decided among the choices in order to select the cleanup remedy for the Site.

In addition to the various cleanup alternatives identified below, demolition of the remaining buildings and structures on the Site and use of the Ruston/North Tacoma residential soils as a sub-base for the Site wide cap were evaluated. In addition to the cleanup alternatives selected, long-term operation and maintenance of the cleanup activities and coordination with Site redevelopment is necessary.

The following section summarizes the cleanup activities under each of the FS alternatives and their estimated costs.

### 7.1 SUMMARY OF ALTERNATIVES

#### Plant Site-Soils (and Slag Peninsula)

Several cleanup alternatives were evaluated in the FS for plant site soils (PSS), slag at the plant site, and the slag peninsula.

PSS-1 is "no action." This alternative means that no further cleanup actions would be performed. This alternative is included to serve as a baseline for the evaluation of other alternatives.

PSS-2 is "limited action" and would focus on restricting access to the Site by fences with warning signs and deed restrictions to prohibit wells from being drilled into contaminated ground water and future use or development on the Site. The estimated cost of this alternative (capital plus operation and maintenance) for both PSS and the slag peninsula is \$1.5 million and the estimated time to install fencing and warning signs is one month (\$1.5 million and one month).

PSS-3 includes two types of caps for the plant site and slag peninsula and three different possibilities for excavation and disposal of soil. In general, the purposes of a cap are to prevent the direct contact of people, animals, and surface water with contaminated soils and slag, to prevent contaminated soil from being wind-blown, and to reduce movement of soil contaminants through surface water into ground water. A cap can also be used to make drainage/grade improvements and to prevent contaminated surface water from pooling on the Site.

#### Caps:

PSS-3A A low permeability ( $10^{-7}$  seconds/centimeter) asphalt cap on areas of the plant site and the slag peninsula that are not currently paved (\$6.3 million and three months).

PSS-3B Soil cap over entire plant site and the slag peninsula that includes a Ruston/North Tacoma residential soils sub-base, low-permeability clay layer, gravel drainage layer, and clean topsoil, see Figure 7-1 (\$7.6 million and five to seven years).

Excavation/Disposal:

PSS-3C Excavate soil and granular slag from the source areas (see Figure 1-1); dispose of materials, together with demolition debris and Study Area soils, in an OCF, a hazardous waste landfill with a low permeability liner and cap, leak detection, collection and removal system, leachate collection and removal system and surface run-on and run-off control systems, located in the current parking lot, see Figure 7-2. (\$23.5 million and seven years).

PSS-3D Same as PSS-3C but dispose excavated materials in an OCF located in the plant slag area (\$23.7 million and seven years).

PSS-3E Excavate, treat, and dispose source area soils and demolition debris in an off-site hazardous waste landfill (\$75 million and six months).

Estimates of Materials To Be Excavated (in cubic yards)\*

•	Arsenic Kitchen . . . .	62,000.00
•	Cooling Pond . . . . .	18,100.00
•	Stack Hill. . . . .	54,000.00**
•	Copper Refinery . . . .	14,050.00
•	Fine Ore Bin. . . . .	9,850.00
•	Demolition Debris . . .	82,000.00
	SUBTOTAL . . . . .	240,000.00
•	Residential Soils . . .	187,000.00
	TOTAL . . . . .	427,000.00

\* The Southeast Area of the Plant is not included because it is not practicable to excavate the wood debris buried in slag that is contaminating the ground water, see Section 8 - Implementability.

\*\* This estimate includes 39,700 cubic yards from and around the car and railroad tunnels.



by armoring, the creation of pocket beaches, mudflats and vegetated shallows will be evaluated. Sloping and/or cutbacks may be used and shoreline irregularity can be designed to support future mitigation of the marine biota. Mitigation may occur at the Asarco Site or another location off the Asarco property.

#### (6) Implementability

Treatment of source area soils using a solidification/stabilization method is implementable. With the exception of the following practical limitations, excavation of source area soils is implementable. Some of the practical limitations on excavating soil from the source areas include:

- (a) Natural features. In the arsenic kitchen area soil excavation will be limited due to the presence of a silt aquitard that is beneath the soils. The aquitard acts as a natural protective barrier preventing metals from moving into the deepest groundwater aquifer on the site. EPA believes that it would be detrimental to the lower aquifer to excavate some or all of this protective silt barrier even though the upper portions of it may contain metals with elevated concentrations of contaminants.
- (b) Man-made features. It is estimated that 15 million tons, or approximately 40 acres, of slag make up the plant area and the slag peninsula. Previous plant site investigations show that slag contains up to 25,000 parts per million arsenic, copper and lead. Excavation of all of this slag is not practicable, however, because of its large volume, the potential for fractured slag to reach the bay during excavation, and the cost to dispose this volume of material.

The copper refinery and the fine ore bins areas include both contaminated soil and slag. If, after soil removal, these areas continue to act as significant sources of groundwater contamination, EPA will evaluate whether further excavation of slag is necessary.

In the southeast plant area, the combination of organic constituents such as DMA and buried sawdust appear to enhance the mobility of metals in slag, resulting in high concentrations of metals in ground water. The sawdust, however, is buried 25 to 30 feet in slag and under saturated, highly permeable conditions adjacent to the shoreline. Excavation through the slag to remove the sawdust at these depths is not technically practicable.

Otherwise, soils in the arsenic kitchen, stack hill, cooling pond, copper refinery and fine ore bins area can be removed with conventional excavation techniques. Diversion trenches and other techniques to dewater source area soils prior to excavation would need to be used and are implementable when carefully designed and constructed. Treatment or disposal of contaminated water resulting from dewatering is implementable.

#### OCF

An OCF can be built in either the parking lot or arsenic kitchen areas of the Site. One concern regarding implementability is whether the OCF will have sufficient capacity for on-site soils and debris. Adding some capacity to the bermed structure in the parking lot and to the circular earth berm in the arsenic kitchen area prior to completion of the structure may be possible by increasing its height. However, the ability to "add" height is limited by the need for structural stability and by future uses of the Site. Capacity could also be added to the linear design. Capacity could not be added once the circular concrete tank is constructed.

Off-site disposal would probably require the construction of a staging area. Currently there is no railroad access to the site and trucks would have to be used to transport excavated soils and demolition debris to the staging area.

#### Capping the Site

Capping with either low permeability asphalt or soil is possible. For either type of cap it would be necessary to regrade the site and assure that several drainage and ponding areas on the site are eliminated. In general, capping would use common conventional construction techniques that have been proven reliable. Maintenance would be required for both types of caps but would be more intensive for the asphalt cap and would require annual crack sealing and seal coats.

**TABLE B-3. ARSENIC CONCENTRATIONS FOR SOIL AND CLASS III GROUND WATER  
IN THE SOURCE AREAS**

ARSENIC KITCHEN

Surface Soil (ppm)	Subsurface Soil >1.5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: 33,225	Max: 262,500	Max: N/A	Max: 117	6
Mean: 16,174	Mean: 7,819			
Min: 2,020	Min: 6.6			

COPPER REFINERY

Surface Soil (ppm)	Subsurface Soil >1.5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: N/A	Max: 3,250	Max: 0.271	Max: 0.277	6
Mean: N/A	Mean: 601			
Min: N/A	Min: 3.3			

STACK HILL

Surface Soil (ppm)	Subsurface Soil >3 in (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: 3,450	Max: 3,025	Max: N/A	Max: 4.542	6
Mean: 1,389	Mean: 402			
Min: 112	Min: 0.18			

TABLE B-3. ARSENIC CONCENTRATIONS FOR SOIL AND CLASS III GROUND WATER  
IN THE SOURCE AREAS (Continued)

FINE ORE BIN BUILDING

Surface Soil (ppm)	Subsurface Soil >7 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: N/A	Max: 1,180	Max: 31	Max: 2.8	6
Mean: N/A	Mean: 643			
Min: N/A	Min: 8			

S.E. Plant area

Surface Soil (ppm)	Subsurface Soil >5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: N/A	Max: 24,950	Max: 51.69	Max: 1.5	6
Mean: N/A	Mean: 4,084			
Min: N/A	Min: 10			

**TABLE B-4. COPPER CONCENTRATIONS FOR SOIL AND CLASS III GROUND WATER IN THE SOURCE AREAS**

ARSENIC KITCHEN

Surface Soil (ppm)	Subsurface Soil >1.5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: 37,375	Max: 53,250	Max: N/A	Max: 0.0051	40
Mean: 15,308	Mean: 2,669			
Min: 4,838	Min: 8			

COPPER REFINERY

Surface Soil (ppm)	Subsurface Soil >2.5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: N/A	Max: 16,700	Max: 0.914	Max: 2.8	40
Mean: N/A	Mean: 2,159			
Min: N/A	Min: 29			

STACK HILL

Surface Soil (ppm)	Subsurface Soil >1.5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: 2,600	Max: 5,750	Max: N/A	Max: 33	40
Mean: 2,309	Mean: 439			
Min: 2,068	Min: 2			

COOLING POND

Surface Soil (ppm)	Subsurface Soil >3 in (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: 341,250	Max: 1,250	Max: N/A	Max: 0.011	40
Mean: 59,423	Mean: 122			
Min: 201	Min: 0			

**TABLE B-4. COPPER CONCENTRATIONS FOR SOIL AND CLASS III GROUND WATER IN  
THE SOURCE AREAS (Continued)**

FINE ORE BIN BUILDING

Surface Soil (ppm)	Subsurface Soil >7 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: N/A	Max: 1,980	Max: 0.14	Max: 10.2	40
Mean: N/A	Mean: 1,230			
Min: N/A	Min: 60			

S.E. PLANT AREA

Surface Soil (ppm)	Subsurface Soil > 5 ft (ppm)	Class III GW Slag (µg/L)	Class III GW Marine Sands (µg/L)	EPA GW PRG (µg/L)
Max: N/A	Max: 10,975	Max: 0.122	Max: 0.008	40
Mean: N/A	Mean: 2,246			
Min: N/A	Min: 0.8			

TABLE B-5. REASONABLE MAXIMUM EXPOSURE ASSUMPTIONS  
FOR RESIDENTIAL USE

Exposure Group	Exposure Route	Age Group (years)	Body Weight (kg)	Contact Rate	Frequency (days/years)	Duration (years)
Onsite Residents	inhalation	0-30	70	20 m3/day	350	30
	soil ingestion	0-6	15	200 mg/day	350	6
		6-30	70	100 mg/day	350	24
	slag ingestion	0-61	15	110 mg/day	350	6
		6-301	70	55 mg/day	350	24
		0-60	15	22.5 mg/day	350	6
		6-300	70	22.25 mg/day	350	24
	dermala	0-6	15	3900 mg/day	350	6
		6-30	70	1900 mg/day	263	24
				5000 mg/day	87	24
	leafy vegs.	0-6	15	0.3 mg/day	40	6
		6-30	70	1.4 mg/day	40	24
	root vegs.	0-6	15	1.5 g/day	69	6
		6-30	70	2.5 g/day	69	24
	water	0-30	70	2 L/day	350	30
Offsite Residential	inhalation	0-30	70	20m3/day	350	30
Recreational Visitor	inhalationb	0-30				
	soil ingestion	0-6	15	90 mg/day	208, 52, 12	6
		6-30	70	45 mg.day	208, 52, 12	24
	slag ingestion	0-6	15	90 mg/day	208	6
		6-30	70	45 mg/day	208	24
	dermala	0-6	15	12000	208, 52, 12	6
		6-30	70	mg/day	156, 39, 9	24
				1900 mg/day	52, 13, 3	24
				5000 mg/day		
	fishc	0-30				

Trespasser	inhalation <sup>b</sup>	6-30				
	soil ingestion	6-30	70	45 mg/day	24	24
	slag ingestion	6-30	70	45 mg/day	24	24
	dermal <sup>a</sup>	6-30	70	1900 mg/day	18	24
				5000 mg/day	6	24

- a Skin area available to contact per day in cm<sup>2</sup> is multiplied by a soil/skin adherence factor factor of 1.0 mg/cm<sup>2</sup>, giving units in mg/day.
- b Evaluated qualitatively.
- c The fish pathway is evaluated by comparison of ground-water concentrations to ambient water quality criteria.
- 1 Indoor slag ingestion.
- 2 Outdoor slag ingestion.

TABLE B-6. SLOPE FACTORS FOR CANCER-CAUSING CHEMICALS

CHEMICAL	EXPOSURE ROUTE	CRITERIA VALUE <sup>a</sup>	WEIGHT OF EVIDENCE CLASS <sup>b</sup>	TOXIC ENDPOINT	SOURCE
Arsenic	inhalation	15 <sup>c</sup>	A	lung cancer	IRIS
	Oral	1.75	A	skin cancer	IRIS
Beryllium	Oral	4.3	B2	unspecified tumor locations by injection	IRIS
Cadmium	inhalation	6.3	B1	lung tumors	IRIS
Chromium VI	inhalation	42	A	lung tumors	IRIS
Lead		B2	B2	renal tumors in rats, no criteria values set	IRIS
Nickel	inhalation	B1	A	lung cancer	IRIS <sup>d</sup>
PAHs <sup>e</sup>	oral	A	B2	stomach tumors	IRIS
PCBs	oral	7.7	B2	liver tumors	IRIS
	Dermal	9	B2	liver tumors	see text
Aniline	Oral <sup>f</sup>	0.0056	B2	spleen and body cavity tumors in rats	IRIS

IRIS Integrated Risk Information System, U.S. EPA (1993b).

a Units (mg/kg/day)<sup>-1</sup>

b Classification definitions: A - Human Carcinogen, sufficient evidence in humans.  
 B1 - Probable Human Carcinogen, limited human data available.  
 B2 - Probable Human Carcinogen, sufficient evidence in animals, inadequate or no evidence in humans.  
 C - Possible Human Carcinogen, limited animal evidence.

c The IRIS inhalation slope factor for arsenic is based on an administered dose from occupational exposure, see text.

d IRIS lists a unit risk factor is  $\mu\text{g}/\text{m}^3$  equivalent to 0.84 (mg/kg/day)<sup>-1</sup> for nickel refinery dust.

e The 7 carcinogenic PAHs are: benzo(a)anthracene, benzo(b)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and ideno(1,2,3-cd)pyrene.

f The exposure route for aniline is through ingestion of seafood exposed to aniline in Commencement Bay.



TABLE B-7. REFERENCE DOSES FOR NON-CANCER CAUSING CHEMICALS

CHEMICAL	EXPOSURE ROUTE	RFD/RFCa	UNCERTAINTY FACTOR	RFD/RFC CONFIDENCE	TOXIC ENDPOINT	SOURCE
Antimony	Oral	0.0004	1000	Low	reduced lifespan, altered cholesterol levels	IRIS
Arsenic	Oral	0.0003-0.0008	3	Medium	hyperpigmentation, hyperkeratosis of skin	Glass & SAIC (1992)
Beryllium	Oral	0.005	100	Low	no adverse effects at this dose	IRIS
Cadmium	Oral	0.0005 (water)	10	High	proteins present in urine	IRIS
		0.001 (food)	10	High		
	Dermal	0.000025		Low	proteins present in urine	see text
Chromium Vi	Oral	0.005	500	Low	no adverse effects at this dose	IRIS
Copper	Oral	0.04			gastrointestinal irritation, flu-like disease	HEAST
Lead	Oral	500 mg/day			neurological and behavioral effect	U.S. EPA (1990e)
Manganese	Oral	0.005 (water)	1	Medium/low	central nervous system effects	IRIS
		0.14 (food)	1	Medium	central nervous system effects	IRIS
Mercury	Oral	0.0003	1000		kidney effects	HEAST
	Inhalation	0.0003	30		neurological	HEAST
Nickel	Oral	0.02	300	Medium	neonatal mortality, dermatological effects	IRIS
Selenium	Oral	0.005	3	High	selenium poisoning, biochemical alterations	IRIS
Silver	Oral	0.005	3	Low	skin discoloration	IRIS
Thallium	Oral	0.00007	3000		hair loss, possible liver effects	HEAST
Zinc	Oral	0.2	10		ANEMIA	HEAST <sup>b</sup>

IRIS Integrated Risk Information System, U.S. EPA (1993b).

HEAST Health Effects Assessment Summary Tables, U.S. EPA (1992d).

RFC Reference Concentration.

RFD Reference Dose.

a Unites of Oral RfD are mg/kg/day; Units of Inhalation are mg/m<sup>3</sup>, unless noted.

b Results of the uptake/biokinetic model (Glass and SAIC, 1992) is used to assess lead in soil for the residential scenario.